BRAIN DRAIN

Indian National Science Academy
New Delhi

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Editor of Publications, INSA
Professor SK Malik, FNA

Editorial Staff
J. Saketharaman, AES-I
Rajan Phull, SO-I

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Preface

There is no gainsaying that economic development and defence preparedness of a nation is status in science and technology. The rapid development of western nations since Industrial Revolution is linked to their leadership in science and technology. The prominent position of United States of America since World War II as the most powerful nation is definitely due to its substantial efforts to remain on the top in science and technology.

India remained a prosperous and strong nation as long as its science base was strong and there was spirit of innovation amongst its people. However, history reminds us that many a time huge Indian armies outnumbering their enemies were routed due to technology inferior to that of the invaders. The nation had to pay a heavy price and had to endure colonial rule for a long period.

After Independence, India decided through its Parliament to ameliorate the condition of its people through science and technology. Bodies like ICAR, ICM, CSIR, DST, DBT, UGC, etc were constituted to promote research in various areas. Indian universities produced a large number of scientists, engineers and technologists. Many of them went for higher studies abroad and returned to the country to fill the available positions. However, the number of available positions soon dwindled for even well trained persons. This has been accentuated due to faulty manpower planning, wrong selection procedures, regional considerations and inbreeding. This has led to almost a unidirectional flow of talent to western countries. This is not only because of easy life devoid of daily hassles but also due to job satisfaction enjoyed by them and the respect they commanded in their profession. This has been further aggravated due to drop in admissions of good students in basic sciences. Today, we are in an unenviable situation where good students don't seek admission while those who leave its shores never return. If we don't take adequate steps now, it will lead to disastrous results for the country. It was this concern that INSA decided to hold a Seminar on 'Nurturing Scientific Talent in India' so that the problem could be discussed dispassionately. It was felt that we should invite both experienced and young scientists. I am glad that many of them attended the seminar and some of them have made valuable suggestions in their articles in this pamphlet.

Our feeling is that when a person is recruited from outside India, he should be provided with adequate infrastructure, reasonable amount of seed money for setting up shop and all the encouragement for submitting research projects to grant giving agencies. We are sure people will come back. After all, we all love our home and we lose a part of 'our self' when we try to settle abroad.

DVS Jain and CM Gupta
Conveners

Editor's Note

Sometime ago the Academy organized a Special Seminar on "Nurturing of Scientific Talent in India" with the idea of analysing the various causes for movement of some of the best Indian brains out of the country for want of better educational and technical research opportunities and for greater emoluments, conducive environment for creativity and higher standard of living. The Seminar was attended not only by Fellows and eminent Indian scientists but also by a large number of students and research scholars. After stimulating discussions several valuable suggestions were made by the participants.

A collection of articles presented at the Seminar has been brought out in this booklet with the hope that they will engender fresh thinking and assist in evolving plans to tackle the various issues involved. The views expressed here are of individuals and not of the Academy. The purpose is to present to the readers the diverse opinions that exist. I am grateful to the speaker who have sent in their articles and to Dr. Ashok Jain, formerly Director, NISTADS and NISCOM, New Delhi, for providing useful information with available data. I deeply appreciate the efforts made by Shri J. Saketharaman, AES (Publ.), in the production of this booklet.

S K Malik
Editor of Publications, INSA

New Delhi
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Some Emerging Issues in Brain Drain

Ashok Jain

Former Director, National Institute of Science, Technology & Development Studies, Dr. K.S.Krishnan Marg, New Delhi-110012

Introduction

In this paper we begin by reviewing the available data on brain drain and point out some key issues that emerge from it. We then argue that as part of science is being viewed as an activity leading to intellectual property, brain drain can no longer be understood only as physical migration of people; migration of research across national boundaries has become an important dimension of brain drain. Finally we point out that causes of brain drain within the framework of economic factors do not provide a comprehensive understanding; a less noticed sociological perspective is important.

The Data

Reliable up-to-date estimates of Indian scientific and technical personnel working abroad is relatively scarce. The available data in the literature are summarised below :

- 21,094 engineers migrated from India to the U.S.A. during 1966-86 resulting in loss of U.S.$ 10 billion to India.[1]
- 324,000 highly qualified scientific and technical humanpower migrated from India up to 1985.
- 30.5% to U.S.A (up from 9.4% of total up to 1961), 7.8% to U.K. (down from 64% of total up to 1961), 10.3% to Canada (up from 4.4% of total up to 1961), 23% to West Asia (up from 4.7% of total up to 1962) and 28.1 to other countries. (Centre for Research, Planning and Action 1989 quoted in Mahanti *et al* 1995)[1].
- Ratio of migrant S&T population to domestic stock as of 1985 : 15.3%.

32.8%	Engineers and technologists (excludes diploma holders)
28.0%	Physicians and Surgeons
5.7%	Scientists
21.6%	Other technical professionals
15.3%	All categories[1]

- I.I.Ts Percentage Alumni Abroad: 23 to 28%

Delhi	23.1% during 1980-90 (Deshmukh *et al* 1997)[4]
Bombay	21.4% during 1973-87 (Sukhatme 1990)[3]
Madras	25-28% during 1964-87 (Anath *et al* 1989)[2]

- All India Institute of Medical Sciences, New Delhi : 46%.

Out of 1224 students from 25 batches during 1956 to 1980, 563 (46%) were abroad, (Kalra *et al* 1992).[5]

- Expected migration : from 410,000 in 1990 to 540,000 in 2000 A.D.

540,000 Indian Scientists and high level technicins will be working abroad by the turn of the century, as compared with about 410,000 in 1990.

Estimated annual brain drain is 5,500 to 6,500, about 90% to the U.S. (Jain 1994).[6]

The above data, besides numerical estimates, brings out three main issues:

(i) Despite the concerns of the media, the public and decision makers, no system is in place to collect and analyze information on Indians who after acquiring S&T skills and education in Indian institutions migrate to other countries. Obvious suggestion of seeking cooperation of migration authorities in the recipient countries is not as simple to implement as it sounds. Such negotiations may have to follow multilateral rather than bilateral route. Organisations like International International Labour Organisation will have to provide a platform. India is not alone in its concern with this issue; increased migration of S&T personnel across nations is a global trend attracting the attention of industrialized and industrializing countries. A system for collection and dissemination of information is required.

(ii) The second issue emerges from the data on the ratio of migrant S&T personnel to domestic stock. The data show that in terms of magnitude of migrations from India, scientists account for the lowest (5.7%). Major outflow is from India's engineering colleges (32.8% of domestic stock) followed by medical colleges and institutions (28.0% of domestic stock). Yet for these professions I.I.Ts for engineers and technologists and All India Institute of Medical Sciences, for physicians and surgeons, which contribute a very small fraction of the domestic stock,

are the only institutions studied and reported in the literature. Thus the sample of institutions for study and understanding of brain drain chosen so far has been from amongst the elite institutions. Engineering and medical colleges that produce the bulk of trained humanpower and contribute a major proportion to migration have remained relatively unexamined. This overall focus on 'elite' also explains the importance given by the reported studies to the migration of scientists although their share is the lowest. This imbalance in examining brain drains needs rectification.

Migration of Researchers and of Research: Migration in relation to domestic stock of scientists has another important dimension. This relates to the declining trend in the annual output of science graduates from Indian universities (Bhargava *et al* 1994)[7] and the possibility that physical migration out of India may not in future remain the only route available to foreign countries for meeting their requirements of scientific personnel. Regarding the declining trend, movement away from higher education in Science (M.Sc. and Ph. D.) is not unique to India, like Japan, U.S.and of Europe (Jain 1994)[6]. One could surmise that this reflects declining demand for highly qualified science personnel in these countries. Yet indications are to the contrary. These countries have started outsourcing their research requirements to Indian institutions, foreign firms are setting up research centres in India and their Universities are strengthening teaching linkages with Indian Universities. The demand for research and consequently of trained scientific humanpower in Japan, U.S. or Europe is thus not declining, rather; a portion of the demand is being met by bringing the research to India instead of taking the Indian researcher to the research site.

In the absence of full data it is not possible to come to a definite conclusion but it appears that it has, become necessary to think of 'migration of research' in addition to migration of researcher. One would have considered migration of research as an irrelevant concept in an environment when scientists were viewed as contributors to the global pool of knowledge freely accessible to all. 'Science' environment has however changed: a portion of scientific humanpower is engaged in science linked to intellectual property, the ownership of which may lie fully or partially outside the country where the scientific humanpower is. It is in this context that the term 'migration of research' as a new but emerging

dimension of brain-drain acquires importance. This, however, is specific to scientific personnel. It clearly does not directly concern the engineers, technologists, physicians, surgeons and technicians. Requirment of such personnel will continue to be met by physical migration and movement.

Causes of Brain-Drain: The existing literature on brain-drain seeks to explain the phenomenon from a variety of perspectives. The dominant theme has been around an economic perspective, i.e., 'Brains go where money is'. Better facilities, higher standards of living, unemployment in India, low salaries are explanations that form part of the 'economic perspective.' For a concise review see 'Critical Appraisal of Brain Drain Studies' Chapter 1 in Mahanti *et al* (1995)[1].

A less discussed and yet significant perspective especially in case of scientists is the sociological perspective brought to light by late Professor Sukhamoy Chakraborty in a meeting of the Advisory Board of the Council of Scientific & Industrial Research. The sociological perspective views brain drain or the desire to emigrate as a consequence of the absence of effective scientific community within India. (Mahanti *et al* 1995)[1]. Need for explanation beyond the economic dimension was first brought out by Amartya Sen in the study of brain-drain in the Third World (Sen 1973).[8]

On the inadequacy of an economic explanation, Sen commented (Sen *ibid* page 402).[8]

"....Some of the usual explanations, such as income difference, distance, travel cost, or quotas, are of so little use in explaining inter-country variations of immigration of natural scientists, social scientists, engineers and doctors into the United States from the underdeveloped countries."

Sen, contradicting the conventional understanding based on higher incomes etc. in developed countries as the most attractive factor for emigration from developing countries concludes :

"Since income differences do not appear to explain variations of immigration into the United States, it is unlikely that the brain drain to America can be reduced significantly just by raising salary level of scientists, engineers and doctors in the underdeveloped countries."

In pursuance of an understanding of brain drain beyond the economic factors, the National Institute of Science Technology and Development Studies (NISTADS) of CSIR conducted a study in 1993-94 of 17 research groups at the Indian Institute of Chemical Biology, Indian Association for the Cultivation

of Science, National Chemical Laboratory, Indian Institute of Science, Physical Research Laboratory and Tata Institute for Fundamental Research. The results of that study are available in a book form (Mahanti *et al* 1995)[1]. The sociological perspective revealed by the study may be summarised as follows (Jain 1994)[6]:

The lack of contacts with foreign colleagues is viewed as a strong driving force for emigration. Scientists working in areas of highly specialized disciplines often feel isolated; no one understands their language or is able to evaluate their work. One key issue related to brain drain is the presence or absence of effective scientific community, especially for those doing research. In India, research facilities in several emerging disciplines were created during the 1990s. Nonetheless, a detailed examination of these efforts indicates that it is only in areas where effective sub-communities of scientists exist that brain drain is minimised. These sub-communities play an essential role in providing an intellectual climate of shared values, a pattern of communication both formal and informal, leadership and direction, mediated through "invisible" colleges, and a system of academic reward and recognition. It is, therefore, not simply an issue of increasing financial investments in research, higher salaries and better equipment. An equally important measure for minimizing brain drain is to improve the "Social " and "cognitive" context for the production of scientific and technical knowledge. Mobility across universities, research institutions, industry and other work places, and greater opportunities for interaction with fellow researchers generate sub-communities essential for retaining highly motivated scientists.

Conclusion

It will be desirable to pursue the sociological perspective more extensively for dealing with the issue of brain drain. Rethink on the conventional meaning of 'brain-drain' as denoting physical migration is also necessary in the changing context of the practice of science, to encompass research migration in addition to researcher migration.

References

1. S. Mahanti, V.V. Krishna, E. Haribabu, Jairath, K. Vinod and A. Basu (1995) *Scientific Communities and Brain Drain - A Sociological Study*, Gyan Publishing House, New Delhi. References to sources of data and comprehensive bibliography on Brain Drain are available in this book.

2. M.S. Anath, K. Ganesh Babu and R. Natarajan (1989), *Data Base for Brain Drain: Institution Based Study*, Indian Institute of Technology, Madras, Department of Science

and Technology, Government of India, New Delhi

3. S.P. Sukhatme (1990), A study on the nature of work and placement of postgraduate Alumni of the Indian Institute of Technology, Bombay, Department of Science and Technology New Delhi.

4. S.G. Deshmukh, K.Ravi Raju and P.N. Rao (1997); *A Study on Brain Drain and Career Profile of I.I.T Delhi Graduates*, Department of Science and Technology, Government of India, New Delhi.

5. Veena Kalra, B.D. Monte, K. Ramachandran, and K.R. Sundaram (1992), *Pilot Study to Evaluate the Phenomenon of Brain Drain among the graduates of All India Institute of Medical Sciences, New Delhi*, Department of Science and Technology, Government of India, New Delhi.

6. Ashok Jain (1994), *A Longing to Belong*, UNESCO Sources No, 61 / September 1994, UNESCO, Paris.

7. S.C. Bhargava, Ashok Jain and Lalita Sharma (1994), Declining trend in M.Sc. and Ph.D. manpower : modelling and forecasting, *Curr. Sci.*,No.2, page 398-400.

8. Amartya Sen (1973), *Brain Drain : Causes and Effects in Science and Technology in Economic Growth*, London, Macmillan. (*Ed.* B.R. Williams)

Some Thoughts on Our Science Education and Research Environment

Mihir Chowdhury, FNA

Indian Association for the Cultivation of Science
Jadavpur, Calcutta-700 032, India

I am happy to note that the Indian National Science Academy has organised a seminar on nurturing scientific talent in India; for, now-a-days I am often smitten by a doubt whether our country is interested in nurturing science, in the true sense of the term. From the inconsistent messages emanating from high and low quarters alike, one gets the feeling that people who matter for the country are managers, engineers or businessmen. A scientist specially one engaged in basic research is constantly kept in the dock for wasting tax-payers money, and the poor fellow feels that he is redundant in this land of Raman, Bose, Saha and Bhabha.

However, I am not sure whether we all mean the same by the word 'scientist', so I shall give my own interpretation of it. A scientist means to me one who is creating new knowledge (basic or applied) in the world context. The definition of 'talent' is also variable, for different fields require different kinds of talent, experience and intelligence. We shall leave out the 'genius' from our discussions for genius defies planning. We shall adopt a mundane view of the seminar topic, such as, how we can improve the quality (and quantity?) of scientific contributions from India. New science, by its very definition, cannot be planned. Nevertheless, one can generate an atmosphere which might foster creativity. I would like to divide the problem in two parts—what we can do for the education of the scientist prior to his productive period and what we can do for providing him with a stimulating environment during his creative phase. It is needless to say that the two are connected.

A. Education

A1. Scientific Facts : Receptive *vs.* Creative Mind

At present what goes in the name of 'science'at school and college stages is nothing but a vast amount of scatterred information about science. A science student is supplied with ready-made answers to the questions or quizzes and is not encouraged to find out the answer by himself or herself. The pleasure of solving the puzzle is gone if the answer is readily supplied. Lack of time, exponential rise of scientific information and ratrace in competitive examinations are frequently given as reasons for this mode of science teaching. If we screen our knowledge to separate the essential from the non-essential and order them properly before passing it over to the next generation, it might be possible to economise on time so that a potential creator of knowledge has leisure hours for reflecting and toying with ideas/ things.

A2. What is the Right Time for Introducing Science Education?

It is necessary to develop language skills, imagination, logical/critical thinking, and appreciation of the world around us before the concepts of science are introduced. Too early sowing of the seed of science in a soil which is not ready yet leads to uncritical acceptance of statements and consequent suppression and eventual death of a questioning mind. I, therefore, suggest that early years of education should be devoted to the preparation of the mind which can very well be done through language, literature and mathematics. Science can wait till the mind starts appreciating and questioning, at which stage the essential concepts may be communicated to the students in an organised way.

A3. Need for Playful Experimentation

We tend to look at science as a grave, awe-inspiring human endeavour and are thwarted thus, from enjoying it. The fact is that most of the scientific discoveries are made through playful new experimentation. In our country a budding scientist reads volumes of science and collects heaps of information but never plays with it. The experiments prescribed in the practical class (at H.S or B.Sc./M.Sc. levels) are rigidly defined and there is no scope to try out variations. It is necessary to develop science as a hobby. In our country the cost of cultivating a hobby acts as the inhibiting factor—an important difference between a budding scientist

in India and one in a scientifically advanced country. Here the science clubs can play a very significant role. I suggest a science club be liberally funded in every school and college so that the motivated student could play with molecules and gadgets.

A4. Motivation

Science does not blossom naturally in our soil and one has to struggle against all odds. I do not know whether the statement that genius is 99% perspiration and 1% inspiration is true in general, but it is certainly true in India. In order to protect the talented from frustration, it is necessary to build up a strong urge in the student to overcome obstacles. Study of the lives and achievements of scientists, specially of our country, might be an effective way to build up this motivation. For example, in Calcutta, I still find C.V.Raman, M.N. Saha, S.N. Bose, J.C. Bose, P.C. Mahalanabis, J.C. Ghosh and P.C. Ray inspiring the present generation of students. Organising visits to well-known laboratories and science museums, reading of popular science journals are other ways of motivating the students at early stages. In the college stage a bright student may be invited to work in a well-known

A5. Creativity and Inter-Disciplinary Area

Virginity of the chosen research field is very important for creativity. The virgin areas go on shifting all the time and most of the time these fall in between two disciplines. In order to cope with this shifting of interdisciplinary virgin areas, it is necessary to offer constantly new courses. The rigidity and compartmentalisation of our present education system have led to the production of stereotypes. A system where the student is given the choice of courses, cutting across the boundaries of various disciplines, has been the most successful in bringing about diversity of interest amongst the scientific population of many countries. The short course system allows the scientist to educate himself later in life simply by sitting in some new courses, if his research problem so demands.

A6. Core Courses - Emphasis on Mathematics and Physics

In science there is certain hierarchy which we tend to forget. This is shown in the diagram (Fig. 1):

A strong mathematical base is necessary in almost all science subjects. When our students enter into research, they realise their deficiency in mathematics and each researcher finds

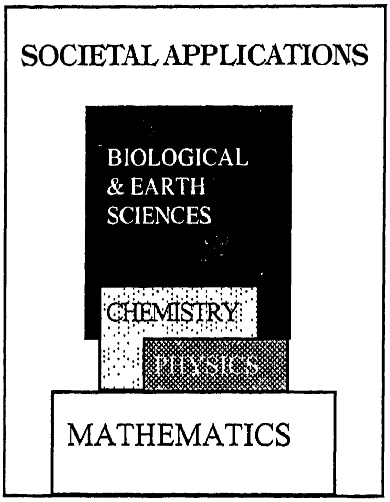

Fig. 1

and difficult theoretical concepts. The mathematical base must be made strong. I also suggest that the core subjects like physics, or chemistry should be given more emphasis in the early years of science education than the applied or derived sciences like biology, geology, and technology.

B. Research Environemnt

B1. Anatomy of a 'Talented' Experimentalist

Let us first have a brief look at the creation centres through the eyes of a young entrant. Let us suppose the young man is an M.Sc. in physical chemistry, did very well in examinations —M.Sc.,NET, GATE and all that, thinks of himself as' talented' and dreams of making a permanent contribution to science which scientists all over the world will acclaim. He applies to the best institutes of India, gets an offer from all of them, and selects one. He does an interesting piece of work, publishes papers in good journals, goes abroad with a post-doctoral fellowship, does good work there and comes back because of patriotic feelings and starts life as a young researcher in India at the age of 32(!). He finds all his contemporaries who opted for engineering have already completed 10 years of service, gone up the ladder of management cadre, has got a beautiful house, a beautiful wife and may be a cute little child besides. He compares his lot—his sufferings all these years from the uncertainty of getting a job. His first task is to find a job which he likes. He has been trained to be a basic scientist and has dreamt of being a very good one. He finds that there are only a few Basic Science Institutes in India - I.I.Sc., T.I.F.R, I.A.C.S., Bose Institute, I.I.C.B., C.C.M.B. etc. But none excepting his parent institute is interested in the line in which he has worked. Because of his good track record he may perhaps go back to his old institute, but then it will be considered as in-breeding and he has to live under the shadow of his Professor. Since by this time he has developed a liking for independence, he perhaps looks for a teaching position in a University or an I.I.T. Because of his credentials, he gets the lecturer's

position in a prestigious University at the age of 34 years. Two valuable years have gone by, by that time. But what does he find? An uninspiring faculty whose one-third only is involved in research, and the economic plight of the researchers are worse than the non-researchers. He being the juniormost in the faculty, his teaching load is the heaviest; he still has the morning and the evening free for research. Where will he get his lab space ? His fights with the departmental head and V.C., earns him a notoriety as being nagging and ill-behaved, and finally gets a small lab space. Another valuable year is gone. Where will he get the money to start the challenging piece of work ? He had been working on an interesting problem with lasers abroad in a laboratory which had three femto-second-systems, two pico-second systems, three CW lasers, plenty of costly optics and detecting electronics, vibration-free-tables, big diffusion pumps etc. etc. He is a pragmatic fellow; he asks for the very minimum—a tunable pulsed dye laser system, pumps detection electronic gadgets etc. Even then, the cost of the project soars to a high figure. The SERC meets after one year, decides that large chunk of money given to a young man is generally wasted and says 'no'; but because his supervisor happens to be an influential man, the project gets sanctioned after pleading with the authorities. Finally, he gets the money after two years. Two more years of his valuable research career are gone. He then places order and the instruments arrive after 1 year and 1 more year goes to solve the teething problems. He is now ready to start working on the little problem he thought about 5 years ago—a problem which he could have solved in four months, perhaps in greater depth if he were still in the U.S.A. Soon after he starts working, he discovers that the machines are breaking down frequently because of power/frequency fluctuation, and the agents do not really have technical experts, good students are refusing to join his university because the central committee of Vice-chancellors/ Directors has decided that they ought to collect fees from the scholars as per new economic policy, no help can be obtained from the workshops, procurement of chemicals, spares takes a long time etc. etc. Let me pause a while at this stage and ask a few questions—

In India, what does 'talent' mean ? Does it mean the ability of doing science, or is it a measure of your ability to manage science - how go-getter you are, how successful you are in convincing your colleagues, your Director, or DST-PAC members, how tactful you are in handling people at the infrastructural sector i.e., electricity, water, workshop, students etc.? Does 'talent' mean pragmatism - shelving difficult challenging problems for the sake of easier and humbler options?

B 2. Some Suggestions

B 2.1 Funding Pattern

Total Quantum

In India about 0.8% of G.N.P. goes for research and development as against 3% in most developed countries. If we consider, in addition, the 100-fold difference in per capita G.N.P., a staggering figure comes out as the difference in investment in sciences. Yet, Indian scientists are criticised for not performing well in competitive research !! It is necessary to increase the quantum of support at least five-fold.

Fund Distribution

Development vs. Scientific

In a country like India it is natural that the major funding should go for developmental work. However, in the new economic situation where the export-import barriers are removed and the competition is global, the development work has to be globally new rather than locally new. For development of a new technology, a very strong basic science infrastructure is needed. I, therefore, call upon the planners to strengthen the places where scientists are being trained in scientific concepts and in the art of research. The main point of science is to generate new knowledge, and new knowledge always has application, sooner or later. The ratio of fund distribution between immediately applicable and not-so-immediately applicable basic research should at least be same as that in other countries.

Equipment vs. Personnel

Our research labs spend disproportionate amount of money on salaries. If 50% of the spending on the salary head is diverted to the equipment head, the laboratories and libraries will be rejuvenated. A scientist can do without a clerk or a bearer, but not without equipment.

Between Starters and Established Scientists

Our future depends on to-day's young scientists. It is the beginners who need the support most. Even if they fail in 50% cases it is worth the gamble. A different generation of equipment is coming up in science and it is becoming increasingly difficult for older scientists to keep up with the changing scenario.

Between Small and Big Projects (Thrust Areas and Centres)

While research projects should generally be judged on the basis of novelty and research capability of the P.I., it is necessary to point out that

most of the current areas of interest in say, Physical chemistry involve very costly tools. For such areas, financial assistance of a different order of magnitude and strong infrastructural support are required. For example, let us choose the area of laser-assisted chemical dynamics in molecular beam. Combined with lasers, the beam technique has allowed scientists all over the world to carry out esoteric experiments which provide the cleanest and the deepest understanding of the behaviour of isolated molecules. If we decide to start work in this direction, we have to take a conscious decision to provide liberal financial (3 crores) and infrastructural support to such projects. These need to be administered on a different footing, and may even have to be freed from the bureaucratic control of the parent institute.

B2.2. Infrastructural Support

Administrative Support

In every university or institute we witness complete breakdown of the administrative machinary. All of us are fully aware of the trouble and delay associated with procurement of chemicals and spares, fabrication of small gadgets at the workshop, procurement of liquid Nitrogen or liquid helium etc. It is necessary to pay attention to these small impediments. If the present situation persists, then the recurring expense money of a project should be given directly to the P.I. along with more freedom to spend the given money.

Power Supply

This is holding up the research work of all our labs. In any advanced country it is unthinkable that a 'talented' researcher has to worry about the power supply. A great number of instrumental breakdowns is because of power/frequency fluctuation. For low power, UPS and for highpower, hot line seems to be the solution.

Technical Support : Fabrication of Facilities

Novel type of experimentation is hardly possible without designing the setup. Scientists of our country are rarely exposed to the instrumentation culture. While building a commercially available equipment is perhaps wastage of time and energy for testing a new phenomenon or hypothesis, one has to design his own setup, by assembling commercially available electronic /optical /vacuum accessories. DST/UGC may organise 6-months' course on instrumentation apart from providing financial support to instrumentation projects. Other suggestions are:—

- Train our scholars in workshop practices and electronics.

- Open well-equipped hobby centres in every college/H.S. school;

Molecular Support

For testing a hypothesis it is often necessary to make tailor made molecules. This requires good cooperation between synthetic chemists and other molecular scientists. Establishment of one commercial laboratory in India for supply of tailor-made molecules would help scientists involved in understanding moleculer behaviour. The cost of getting such molecules made by an international chemical company is too high.

Computational Facilities

There is a high probability of reaping rich dividend from investment in 'Theory' sector. Indians have reputation for good abstract brains; indeed, most of our famous scientists were theoreticians. In this field one has to depend minimally on others; secondly, the cost of computer is low. If a good communication channel exists, theoretical research can be pursued in any institution. We should improve the computational facility of all universities/institutes to provide full support to our theoreticians. It is however, necessary to oversee that theoreticians do not get replaced by numericians.

Communication

The communication field is undergoing a revolution. The internet facility needs to be extended to all universities / institutes. Apart from communication through the internet, face-to-face interaction with scientists of the rest of the world is needed. I suggest that P.I.s be allowed to spend their travel money for attending international symposium, a standard practice all over the world.

B2.3 Incentives

To stop brain-drain from the creative profession, some suggestions have been given in previous sections. Here are some more:

Service Benefits

In the present economic setup, creative people are treated at the same footing as those engaged in routine jobs. I believe creative people need to be pampered by the society. There should be a salary differential from other government jobs, including the purely teaching jobs. Since a researcher usually joins a permanent service quite late in life, either his service period should be extended or additional retirement benefits be provided.

Number of Jobs

It is high time that we carry out subject-wise survey of research and teaching-cum-research jobs in the

country and adjust our input to the profession accordingly. Creativity does not flourish in an atmosphere of frustration. To provide additional jobs, every industry having a turnover exceeding a certain limit may be asked to open a research/development cell in the organisation.

Early Screening and Special Treatment(?)

Some suggest early screening of science talent and special treatment for screened students. This is only possible if we can predict 'talent'. Unfortunately, no one has devised a proper evaluation method. Talent happens to be different in different branches of science and depends largely on the researcher's motivation.

Invited Talks

Asking a young scientist to give a talk at monthly, quarterly or yearly meetings of subject-societies (local or central) is a very effective way of stimulating a researcher. In this matter various science academies, particularly the local chapters, can play a very significant role. At present too many prizes are distributed through doubtful evaluation procedures. A young man often enjoys the publicity more than the science he is doing. This tends to corrupt the academic atmosphere. In the absence of a good evaluation method, prizes could be counter productive. Scientific discussions after a presentation before an august body or a few words of encouragement from an expert in the field are often valued more by a serious scientist than a prize-winning selection by a committee consisting essentially of non-experts.

C. Concluding Remarks

How a budding scientist blossoms depends entirely on the environment. Nurturing science needs sustained thoughtful efforts—not just by a single individual, but by the society collectively. If the society expects direct economic benefit out of this investment, it is going to be disappointed; but indirect benefits are many. More important is, gathering new knowledge is the mandate for man. Indians may be an effective participant in this global program only if they can organise their scientific institutions efficiently. □

Dwindling Talent and Decline of Universities– Any Correlation?

Sushanta Dattagupta, FNA

School of Physical Sciences, Jawaharlal Nehru University
New Delhi-110 067, India

The title of my talk is :"Dwindling talent and decline of universities" and I would like to raise the question: "Is there a correlation between the two phenomena?" There are of course numerous reasons for diminishing scientific talent, an important one being the economic foctor. However, I believe, economic consideration is not the principal reason for dwindling talent. In fact, I agree with the organizers of this symposium who had prefaced their letter to us by saying : "The flight of young talent from scientific research career in the country is not due to low salaries and perks but mainly due to lack of scientifically conducive environment and proper encou-ragement," I believe, quality science emerges when there is excitement for doing science cannot be a 9-5 job: on the contrary, it has to be a fulltime obsession and passion.

Therefore, what we should analyze is how to create a proper environment for inculcating in a young mind the excitement of pursuing science and that is the only way to nurture talent. While there is a complex set of reasons for our inability to do so, in India, one reason is linked with the alarming falling standards of our universities and colleges. This is the thesis of my presentation today within the limited scope of an half an hour's lecture. (Henceforth, when I mention "Universities", that word is meant to encompass "Colleges" as well.)

Statistics

Before we set out on out on our task let us consider certain facts. Here I quote from a document prepared by a panel of the Indian Academy of Sciences on: "University Education in Science."

- Less than one percent of the students who complete 10+2 school years go on to science education at college level. Further, of the total university output of undergraduates each year, approximately one-third are in the sciences.

- Only about 200 students join the Ph.D. programme per year in various Indian institutions.

- Only about 10% awardees of the National Science Talent Search (later expanded into National Talent Search) opt for science at the undergraduate level: and the total number going on to the post-graduate level is even smaller.

This is as far as enrolment is concerned. What about other operational realities of our University system ?Again I quote from the Indian Academy booklet.

- Most universities and colleges do not run as announced in schedules, hold classes and examinations on time and declare results on time.

- The options available to undergraduate students are limited and inflexible. The division into engineering and medical streams at the +2 level itself contributes to the problem. Practically, nowhere can an undergraduate student pursue emerging combinations like biology and mathematics or biology and physics. One still has to choose from old-fashioned combination such as physics, chemistry and mathematics or chemistry, biology and zoology. Even in the IIT's, the option of students moving into science from engineering streams is rarely exercised.

- Too many universities have been established over the years without giving adequate thought to the availability of teachers of acceptable quality. Without any attempt to correct the ills of the existing universities, all too often new ones are created only to face the same problems later.

- Faculty positions in universities appear lacking in prestige in the eyes of the society. In addition, what young people see all too clearly is rampant inbreeding in most universities. Inbreeding has a deep and serious repercussion on the development of science. Science progresses by asking questions on establishesd dogma, Challenging old concepts and proposing new ones. Given our social hierarchy, it is unlikely that a junior faculty member who had been a Ph.D. student of a senior professor in the department would demonstrate independent abilities.

- In most universities one finds low educational standards and a poor academic environment. Colleges are generally underequipped, overcrowded and poorly staffed. Questions from students are often discouraged, and experiments and demonstrations are few.
- At the higher levels of university training teaching remains divorced from research. Quality and excellence in teaching go unrecognized and unrewarded. (This is a point to which I wish to return later.)
- Again to quote from the Indian Academy booklet,"with increasing political influence in higher education, the pursuit of excellence has disappeared and given place, among other things, to commercialization of education. The twin aims of social equity and academic excellence are being seen as opposed to each other. There is no intellectual debate on these overlapping problems, and it is being left to the judiciary and the political leadership to determine the directions open to society."

It is no wonder then that our universities are unable to attract and retain talent. This is an ironic situation because it should be clear to everybody that whoever goes to scientific research is first educated and trained in a university. The basic training must be of a kind and quality that prepares her properly for her subsequent career and this training can be imparted only by a university. It is the university which provides a proper forum for the stimulating interplay of teaching and research, an atmosphere of free thinking without the constraint of time-bound projects. Hence, it is my belief that the way to nurture talent is to nurture our universities.

What Can be Realistically Achieved?

It would be impractical to imagine that all the problems of our universities, mentioned above, can be removed overnight, without massive fundamental changes in our social and political attitude. There is, however, one area to which we scientists can contribute and that will go some way in our endeavour to nurture talent. It is this aspect that I would like to focus onto during the rest of my article.

In the Indian Academy report heavily cited earlier we recognized one important issue. I quote: "It is widely felt that one cause for the sorry state of affairs (in Indian science) is the government's policy of the past half century of establishing chains of specialized research institutions and national laboratories outside the university system, without proper and healthy linkages to the latter. This

policy, especially the disproportionate funding of these institutions, has deprived universities of both talent and material support. Even worse, the access of young motivated students to leaders in various fields of science-natural in university setting in developed countries and so essential to creative work at a young age—has become virtually impossible. Thus the soil in which the scientists of the future should grow has been deprived of some of its most important nutrients."

I come from a relatively better endowed university. Even then, there is no comparison between what we can offer to our faculty in terms of housing, infrastructural facilities (so essential for experimental science), library, office-comfort (air-conditioning is considered an avoidable luxury) and so on, and what a national laboratory can provide. Besides, the unimaginative promotion policies and are generally viewed as too "noisy "for doing science. It is not surprising then that our best talents, however small in number they are, are lured away to the national institutes causing further impoverishment of the university system.

In what way is this state of affairs detrimental to our efforts towards nurturing of scientific talent? I had mentioned earlier how important it is to be a good researcher in order to be a good teacher. A research mind invariably unravels deep insight into a subject and that is motivating indeed for a young learner. By pushing our best scientific brains into the national institutes we are depriving our youth of a large number of potentially inspiring teachers. (It is not uncommon to hear how a few excellent teachers have been able to convert even B. Tech (Engineering) students to research in basic sciences.)

I would even go on to make another point that despite excellent facilities extant in national laboratories commensurate results are not forthcoming because:

a) merely doing research without continual interaction with young students is bound to be stale, after a period. This may be the reason why many good people in research institutes fizzle out and become unproductive;

b) national labs, due to their very organizational set up, are sometimes hierarchical in structure. This often leads to curtailment of academic freedom which in itself does not yield a conducive environment for nurturing talent; and

c) there is considerable inbreeding, even in national institutes.

A Few Suggestions

1. Our Indian Academy panel made the following recommendations which I would wish to reiterate here. "New institutes or centres created should be within the overall university system, but administratively independent and autonomous." This would hopefully help maintain schedules and eliminate political interference.

2. India is a vast country which is bound to have heterogeneity in standards, especially in the university sector. The situation is not too different from America. We should recognize this and accept the fact that while a majority of universities may be of the type of vocational training centres, there is a crying need to strengthen, say 25-30 existing universities with strong research component juxtaposed with teaching programmes.

3. Our experiece in Jawaharlal Nehru University is that there is a lot of young talent to be tapped from non-urban, non-sophisticated background. For this, there should be an all India recruitment system.

4. The 25-30 odd universities I mentioned should be made free from the (earlier discussed) conflicting dichotomy between "social equity and academic excellence." Yet, at the same time, they must demand accountability from their faculty, perhaps by introducing a tenure system.

5. It is crucial to have academic cooperation between universities and national laboratories, including joint research, teaching and training (of students) programmes and identification of adjunct faculty. National laboratories are endowed with expensive equipment, beyond the reach of universities. But a close symbiosis of the two sectors will enable optimum utilization of our national resources. It would help if scientists from national labs go a little out of their ways to interact with university teachers and make available their (superior) computer and library facilities to users at large. An active Visitors Programme through which university people can come and interact with scientists in national institutes, will also be useful. This would go a long way in attracting back young talent into scientifically active career. In this respect, creation of Inter-University Centres (IUC) has been a laudable step.

6. Identifying young talents and providing them with summer fellowships to work in active research centres, such as being undertaken by the Jawaharlal Nehru Centre for Advanced Scientific Research, is a praiseworthy effort. I hope, other agencies will emulate the JNCASR example.

7. Finally, I think, we are too defensive to "sell" scientific research as a career prospect to our young talent, yes, it is true that we are paid badly and we face many hardships, but why can we not highlight the positive side, namely the leisure that comes with our academic job? Would other professions allow so much free time, which we can profitably use for sheer intellectual pursuit? We must reach out to undergraduate college students and convince them that the life of an Academic is of good quality and may even be preferable to that of an Executive, who is paid much better but is forced to live off his suitcase!

Before concluding, I would urge the Fellowship of the Academy and especially the president to make a serious effort, perhaps in conjunction with other academies, to convey to the policy makers the gravity of the situation, as articulated by speakers in this Symposium. Failure to do so would make our efforts here another fruitless intellectual exercise. □

Nurturing Scientific Talent in India: Changing Perspectives

Ashok Sahni, FNA

Centre of Advanced Study in Geology
Panjab University, Chandigarh-160014, India

The history of science clearly demonstrates that it is only a small minority who has dared to probe and breach the frontiers of science and extract its well kept secrets, and that these few individuals were exceptionally talented. Yet their achievements would not have been possible without the dedicated effort and support of countless others, perhaps less talented, who diligently sought to build up a body of scientific data using which, the exceptionally gifted could make their breakthroughs. Truly, one is reminded of the remark of one of the most eminent physicists of our times, who said that if he were able to see far it was only because he stood on the shoulder of giants ! Talent, therefore, is an exceptional gift, which has many guises, talent for imagination and creativity, a talent for diligence and hard work and above all, a talent for recognizing those who are talented! The name of Professor Hardy comes immediately to mind, for had it not been for his intuition of recognizing excellence, it is possible that the genius of Ramanujan would have been lost to the world forever. In this article, I wish to express my own feelings on the important issue of the recognition of talent and its nurturing in India.

In my opinion, talent is best recognized at an early age, preferably at school. Later, as an individual grows, his mind becomes less flexible to new ideas and perceptions. Paradoxically enough, in the competitive environment of India today, natural talent seems to be suppressed in the strongly regimented world of the school curricula, quizzes and routine examinations, which tend to kill the instinctive creativity of the talented student. I am conscious while writing this, that I am addressing only part of

the problem and considering only those schools in urban cities, which have the facilities for imparting some degree of scientific training to students. The majority of our young talent in the small tehsil town and rural sector has to fight an uphill battle to obtain even a modicum of scientific knowledge. Even a genius cannot formulate his ideas without the basic concepts being made available to him! Natural talent has therefore to be recognized early and then left unrestrained to bloom and blossom on its own. It is therefore equally important to have in place systems for recognizing the exceptionally gifted, those imaginative souls who do not want to be shackled by the "conventional truths" of their time, but wish to be left to themselves to find the fulfilment of their own perceptions those systems which are already in place in the Indian school system are devised with specific forms on the recognition of talent hopefully of nurturing it after it has been identified.

X Class-NTSE

The National Talent Search Examination run by the NCERT, New Delhi, is certainly the best known and most prestigious of several talent search programmes which are run mostly at the private level.

The National Talent Search Scheme is sponsored by the National Council of Educational Research and Training, New Delhi with the following avowed objectives:

- To identify brilliant students at the end of Class X and give them financial assistance towards getting good education, so that their talent may develop further and they may serve the discipline as well as the country."

- As per the data of 1986, the scheme awards 750 scholarships including 70 scholarships for Scheduled Castes and Scheduled Tribes each year. Although, the number of scholarships is meagre compared to the total strength of our student community, still I feel that this programme is commendable because it is the first recognized national level talent search examination specially designed by experts for the recognition of talent (though it is not necessarily restricted to science students) Additionally, this programme is further to be commended because it has an inbuilt programme of "nurturing" the awarded candidate throughout his or her educational career till and including a Ph.D. degree. However, I feel that good as this programme is, further improvement could be in the area

of the closer monitoring and perhaps the personal interaction of the awards among themselves or with eminent scientists of our country at least once a year. After all, if the NCERT takes so much trouble to select talented students, it should also take proper care of nurturing them and following their academic progress at a more personal level rather than accepting a "satisfactory progress certificate" in a routine manner.

However, more effort and systems should be devised to "catch" those talented youngsters for whom the present drudgery of school actually saps their natural ability. If a valid case can be made for the recognition of talent at a young age in the field of sports—the training of young gymnasts is an obvious example, I do not see why the same principle cannot be applied to the academically talented. I agree entirely with the mathematician A Selberg who while discussing the exceptional talents of geniuses like Ramanujan, has made the point that —

"The most important lesson that one could draw from Ramanujan's story about the educational system is that allowances should be made for the unusual and perhaps lopsidedly gifted child with very strong interests in one direction, at all stages of the educational system".†

10+2 Professional Level Selection Examinations (Medical and Engineering Colleges)

A series of examinations are conducted at the 10+2 stage, for the recognition of talented students and are organized by various Engineering and Medical Colleges, including the prestigious Joint Entrance Examination of the Indian Institute of Technology. In some ways, these examinations are a better test of talent than the system devised by NTSE mainly because the students are more aware of their long term objectives and more motivated to succeed. The very prestige of the institute conducting the examinations and the promise of a lucrative job or professional career is itself an incentive for the talented student to compete. To my mind, students passing these examinations would be amongst the most talented in our country because these examinations not only test the mental ability of the students but also require a great deal of hard work and perseverence, two essential qualifications for those who wish to make science their profession. Though I lack exact figures, I estimate that about 200000 to 300000 of our top students the talent is recognized in this manner at the +2 level which is virtually a drop

† From talk delivered at the Tata Institute of Fundamental Rasearch, Bombay (January 1998, reproduced in *Resonance*, December 1996, p.91).

in the ocean when one considers the wealth of manpower that is untapped in rural schools.

University Entrance Test

Most Universities now have devised entrance tests for admission of students to the University udergraduate classes. Such admitted students ultimately find their way to university science departments from where they work towards their Bachelor and Master of Science degrees. It is here perhaps that the greatest demoralization sets in and that there is a gradual decline in both the motivation of students and their academic standards. The reasons at the present time are not hard to see because most talented students, even those steadfast to their chosen disciplines, must need jobs or some positions to continue their work. At the present, employment prospects in several basic sciences are not good enough to attract the best talent and specially, in the liberalized economic scenario of India in the 1990's, talent runs where the money is.

Career-oriented Exams (IAS, Banks, etc.)

The next series of examinations at the national level are at the postgraduate level which further depletes the pool of talented students eligible and desirous for a Ph.D. degree at the University. Even at the postgraduate level the cream of talent has been siphoned off in favour of subjects such as Business Management or Computer Applications where employment prospects are bright. Pure and Basic sciences are again the losers.

CSIR-UGC NET Exam

It is true however, that CSIR-UGC NET examination is a step forward in identifying talented students for research in basic field for students coming from different universities where the same standard of grading may not exist.

Nurturing at the Post-Doc Level

I am sure that there are many science administrators who feel that actual nurturing of talent should start at the stage when a young scientist is at the threshold of his career. This would apply not only to those who have returned to the Indian fold after obtaining their specializations abroad. I tend to disagree with this idea on the grounds that such young scientists do not really need "nurturing" in the strict sense of the word. Their needs rather demand adequate laboratory facilities and a great deal of independence to carry our their research projects as they themselves deem fit.

Earth Sciences and the Problem of Recognizing Talent

The core subjects of science at school for instance Mathematics, Physics, Chemistry and Biology receive a lot of attention, other subjects such as earth science usually form the periphery of the curricula or are included piecemeal in several other subjects such as biology (paleaeontology), soils, geomorphology in geography etc. The subject of earth science is a nebulous entity for most Indian students even upto the time when they apply for admission for an undergraduate degree at the University. It is therefore practically impossible in the present circumstances to identify whether a student may or may not have a special aptitude, leaning or inclination for studying earth sciences. This is certainly not the case of instance in a subject such as mathematics—where the aptitude of a student is recognized very early in his school career. It can be argued that aptitude for a certain discipline may not necessarily be the same as talent but in subjects such as earth science, inclination is a necessary component of hidden talent. On the other hand, I am personally aware of several scientists in other countries who formed a love for rocks and minerals and fossils very early in their school career and were motivated enough to pursue the subject for their professional career as well.

Is it then at all possible to recognize and spot talent in subjects such as the earth sciences? I feel that it is, but that in the present day school system, this is not entirely feasible. Earth science draws its strength from several disciplines such as physics, chemistry, mathematics and biology but it shares with several field based disciplines a keen insight into the natural world. While I have heard several students at the school stage saying that they would want to be a physicist or a mathematician when they grow up I do not know of many students who at school have expressed the desire to become a geologist!. This only reflects at the way our educational system is focussed with its emphasis on bookish knowledge rather than emphasis on the great outdoors where the real knowledge is to be found.

In my opinion, every branch of science is as important as the next and if we in India wish to keep pace with the developments in the world in various fields, it is imperative that a school curricula be devised keeping in view the special needs of subjects that do not form the core of the basic sciences. □

The Real Brain Drain

S.P. Sukhatme, FNA

Indian Institute of Technology, Powai, Mumbai-400 076, India

Introduction

In order to nurture scientific talent in a country, a variety of approaches aimed at various levels in the education ladder have to be considered. Talent has to be nurtured at the school level, at the 10+2 level, at the Bachelor's degree level and at the post-graduate and doctoral levels. It is to be noted that the numbers involved reduce significantly as one moves to the higher levels. Also, the talent at the higher levels is more easily identified, because the persons have passed through many levels of filtration. In this paper, attention is specifically focussed on the nurturing of that talent at the higher levels which migrates abroad on a permanent basis and constitutes the 'brain drain'.

The term 'brain drain' refers to the migration on a permanent basis of highly qualified and talented manpower from a country, in which it has been trained at considerable expense, to another country. In India, the problem first assumed importance in the sixties because of changes in US immigration laws which made it possible for a large number of Indians to migrate to the United States. Initially the issue of most concern was the large number of doctors leaving India. In recent years, as the need for Indian doctors in U.S.A. has diminished, the focus has shifted to the large scale migration of engineers and scientists. The purpose of this paper is to present reasonable estimates on the magnitude of this permanent migration from India and results of studies which help in understanding the brain drain as a process. We then introduce a term called the 'real brain drain' and suggest the outlines of a scheme for mitigating its harmful consequences.

Magnitude of the Brain Drain

In the Indian context, the phrase 'brain drain' implies the migration of engineers, doctors, natural scientists, social scientists, and others. The persons migrating possess Bachelor's

degrees, Master's degrees or Doctorates in the above fields. A majority of those with Bachelor's or Master's degrees go abroad initially for higher studies and then stay on.

A study of the literature available on the brain drain from India shows that a number of papers have been written on the subject. These papers identify some of the principal causes of the brain drain and suggest measures for checking this flow of people. However, inspite of the large volume of writing available, reliable data on the magnitude of the outflow are relatively scarce. At the national level, there is no ready data base from which one can come to know the total number of emigrants who leave on an annual basis and can be classified as constituting the brain drain. Reasonable inferences can however be drawn by using data available for U.S.A. because of the fact that much of the brain drain is to that country. Such data are presented in Table-I which gives a break-up of professional, technical and related workers migrating from India to the U.S.A.

Based on the above data, it would be reasonable to estimate that the average annual brain drain to U.S.A. was around 4500 in the seventies. This number has not changed much in the eighties since the immigration quota is fixed by law and has not been altered until recently†. Assuming that the brain drain to U.S.A. is about 85 percent of the total, the current average annual brain drain from India to all countries of the world can be estimated to be 5500. Of these, it is estimated that about 35 to 40% are engineers, 10 to 15% are doctors, 10 to 15% are scientists and the remaining are from other fields like Humanities and Social Sciences, Business Management, etc.

It is worth noting that the brain drain is a small percentage of the annual national output. For example in the case of engineers, the annual output is around 50,000. If one takes the brain drain to be 2000, we get the percentage brain drain to be only about 4. The percentages in the case of the other professions (doctors, scientists, *et al.*) are even smaller.

Understanding the Brain Drain Process

Two detailed studies on the brain drain[1,2] have been conducted at IIT-Bombay with respect to the graduates and postgraduates of the Institute. Apart from helping to quantify the magnitude of the brain drain from an IIT[3], an attempt has also been made to develop an understanding of the brain drain as a process.

† Some changes have taken place in the U.S. Immigration Laws in 1990. Because of this, it is generally expected that there will be an increase in the brain drain.

Table-I: *Break-up of Professional, Technical and Kindred Workers Migrating from India to U.S.A.*

Classification	1970	1972	1974	1976	1978	Average
Engineers	2361	2515	669	900	1153	1472
Natural Scientists	439	702	227	274	385	398
Computer Specialists	-	-	48	82	102	43
Physicians and Surgeons	242	1513	1049	1611	596	1154
Others +	2129	3441	2819	3541	2495	2900
Total for professional, technical and kindered workers	5171	8171	4812	6408	4731	5966
Estimate of brain drain to U.S.A.	4107	6451	3403	4638	3484	4516

Source: Adapted from data presented by S.J. Burki and S.Swamy, 'South Asian Migration to United States ' *Economic and Political Weekly*,.XXII, No.12, p.513 (1987), and R.R. Gulati, 'India's Brain Drain to the U.S.', *Current Science*, 59(4), p.196 (1990).

A fairly good understanding has been obtained by analyzing the replies given by our alumni to a carefully formulated questionnaire. The questions were framed with the intention of developing two methods for understanding the brain drain. In the first method, an attempt was made to trace the professional career of the alumnus by analyzing his initial decision to go abroad or not to go abroad, his decision to settle down abroad or return to India, and his views on life overseas and in India. In the second method, no personal questions were asked. Instead alumni were asked to comment on and rate certain features of life in Western societies and in India that influence Indians in their decision to settle abroad or to return home. Both positive and negative features were considered in these questions. Four important findings emerging from the studies were as follows:

- Data on alumni settled in India showed that a number of them (about 25 percent) had also wanted to go overseas for further studies. Of these, many had secured admission in U.S. universities but could not obtain financial aid. Thus it is evident that the real control on the number who migrate and their break-up professionwise is exercised by the receiving country and its needs.

- As perceived by alumni, the principal positive feature of a western society which encourages Indians to settle there is a 'comfortable standard of living'. 'A commitment to first rate science and technology' is perceived as the next most positive feature. This finding would appear to substantiate the statements often made that firstly 'brains go where money is' and secondly 'brains go

where brains are'. These two positive features of a western society combined with the most dominating negative feature of Indian society as perceived by alumni, viz. the all-pervading presence of a stifling, unresponsive bureaucracy, are the root causes of the brain drain.

- Data on IIT alumni settled abroad showed that most of them took the initial decision to go abroad with the purpose of undergoing further studies. The primary factor influencing this decision was the desire to take advantage of wider and better opportunities abroad. The data also showed that many alumni had not planned on staying back overseas when they went from India initially.
- A large number out of thòse who settle abroad do so without really having planned or made a conscious decision in this regard. They seem to slip gradually into an environment in which the salary and very often the working conditions are excellent and in which the initial opportunities for advancement are good.

The implications of the first and second finding are obvious and disturbing. One arrives at the conclusion that so long as the country remains economically poor and so long as its citizens are free to migrate, there is little prospect of influencing the magnitude of the brain drain by introducing any domestic policy measures. One has to accept the fact that the magnitude of the present outflow is determined by the immigration laws of the richer developed countries. Even the break-up of the outflow in terms of professions is determined by the needs of the receiving countries.

The implications of the third and fourth are also significant. One arrives at the conclusion that if efforts can be made to prevent the gradual alienation of a specific person from his home country (which occurs over a period of time) and if an appropriate placement can be offered to that person within a year or two of his completion of studies then there is a reasonable possibility of his returning home. The first aspect increases the 'pull' factor for returning, while the second aspect reduces the uncertainty associated with returning with nothing in hand.

It should be noted that the above conclusion does not in any way contradict the earlier conclusion that the present magnitude of the brain drain will continue. The first conclusion is concerned with an overall picture of the problem, while the second conclusion is concerned with a specific person in that overall picture.

The Real Brain Drain[4]

Recognizing these facts, what does one do in terms of a policy? Does one continue to do nothing, as has been the case so far, because there seems to be no way to reduce the magnitude of the migration? Does one say that 5500 is not an alarming number worth worrying about in comparison to the total annual output of the country?

The contention which we wish to present in this paper is that we need to worry and do something about this permanent migration, not on account of the fact that it is about 5500 a year but because amongst these 5500 migrants, there are every year a few hundred outstanding individuals.

Personal experience of teaching at an IIT for 25 years shows that although about 150 of our alumni settle down abroad every year and they are in general of a good calibre, there are very wide variations in their abilities and only about 20 or 25 can be classified as being brilliant. Similarly, out of the total number of 5500 persons who migrate, only a few hundred (perhaps three or four hundred) are really brilliant individuals. The permanent loss of these few hundred gifted persons should be a matter of serious concern to the nation and constitutes what may be termed as the 'real' brain drain. Any policy measures which can help to get back some out of this small group of persons would obviously be worth pursuing.

A Scheme to tackle the Real Brain Drain

A scheme is now being described for tackling the problem of the real brain drain and ensuring that a reasonable number of persons coming under this category ultimately work in India. The component steps making up the scheme are: (i) identifying the talented persons who would eventually constitute the real brain drain; (ii) staying in touch with them particularly when they are abroad; (iii) offering suitable job placements in India at an appropriate time; and (iv) retaining the talented persons by offering some incentives for professional development.

Identifying the Talent

The first question which naturally arises is "Can the highly talented individuals who constitute the real brain drain be identified?" This can almost certainly be done in a reasonably objective manner. An appropriate time to select the persons would be when they complete or are close to completing the Bachelor's degree in professions like engineering and medicine, and the Master's degree in fields like the natural and social sciences. Thus the persons selected

would be young men and women mostly in the age group of 21 to 23. The problem is one of identifying a few hundred brilliant students from about 100,000 graduates or postgraduates. This is not as difficult as it seems since the procedure for identification can be set into motion at a much earlier stage, viz. the secondary and the higher secondary stage. A tentative list can be prepared every year based on the results of examinations like the National Talent Search Examination, the higher secondary examination of each board (the top hundred or the top fifty in each board), the pre-engineering and pre-medical tests conducted by many states, the Joint Entrance Examination of the IITs and the All-India examination for admission to medical colleges. This list may contain about 10,000 names. By keeping a track of the academic records and careers of the students who figure in this list, it should be possible to eventually pick out a group of the most talented boys and girls at the end of four or five years when they acquire the degrees of B.E., B.Tech., M.B.B.S., M.Sc., etc. The finalization of the names in this group can be done by committees of eminent scientists, engineers and doctors specially appointed for the purpose. Bodies like the Indian National Science Academy, the Indian Academy of Sciences and the Indian National Academy of Engineering could be specifically requested to assist in the final selection. This would lend prestige and impartiality to the selection process. Once selected, the names and particulars of the persons should be entered into a suitable data base, which is continuously updated with new data and current addresses.

Staying in Touch

A very large fraction of the group identified is likely to go abroad for further studies to some of the best universities. This is inevitable considering the facilities available abroad. It is also quite natural for any young person to have a desire to see the world and be exposed to other cultures. The important thing is not to prevent any person from going abroad, but to ensure that one stays in touch with him or her and prevents the setting in of a sense of alienation from the Indian environment. It is well known that when students from developing countries are abroad, they lose contact with professional, social, economic and even political developments in their country. Most students of science and technology never see newsletters or bulletins of the CSIR, the Department of Atomic Energy, or the Department of Space which carry information on science and technology policies, technological breakthroughs and job opportunities. For the present scheme to be effective, it is vitally important

that every person identified should receive individual copies of some newsletters right through on a continuing basis. Embassies and consulates abroad would have to take this up as a special task.

A second and an equally important aspect is to see that the scholars are brought in touch with leading scientists and engineers from India when these persons go abroad on visits. Apart from the general lectures which such eminent scientists give on campuses abroad, it is necessary to see that they have personal conversations with the scholars to find out what they are doing and how they are progressing. This again is a special task for which the liaison work would have to be done by the concerned science counsellor in our embassy or consulate.

The vital importance of maintaining communication with the scholar throughout his stay abroad cannot be overemphasized, since this greatly helps to strengthen the 'pull' factor for coming home. Thus the success of the later steps is dependent in a large measure on the success of this part of the scheme.

Placement

The most important part of the scheme is the proper placement of each scholar at the end of his educational programme. For the scholar abroad, the usual temptation is the desire to work abroad at least for a year or two. By doing this, he saves some money and at the same time acquires some professional experience.@ It is important to realize however that during this period his mind is still open and he is receptive to the idea of returning home. An offer of a job at home should therefore be made during this period of one or two years. After that the chances of returning home are negligible. This job offer will be weighed by the scholar against what he is likely to get in the United States.

Typically a company or a university abroad invites the person whom they are interested in offering a job to spend a day or two with them. During this period, the organization is able to observe the person at close quarters and see how he might fit in their organization. In turn, the person concerned is able to observe the environment in which he is likely to work, the persons with whom he would be interacting and the nature of work he is likely to do. Indications of what he might be paid are also given.

It is against this competing scenario that a job offer for working in India has to be made. Needless to say there can be no comparison in monetary terms

@ In many cases, the professional experience could mean a post-doctoral fellowship.

between a job in India and one abroad. The salary offered for a job in India can only be commensurate with the existing economic conditions at home. The most important aspects from the point of view of the scholar are that a firm offer of a job should be made to him even when he is abroad and that the nature of the job should suit his plans for working in the future. Very frequently persons applying from abroad to organizations in India are informed that they will be considered for a job only after they return, at which time they should contact the Indian organization. Alternatively, they are informed that they should wait for an advertisement and then apply to the organization in the prescribed form. More often than not, an enquiry for a job in India does not even result in a reply. If the nation is really serious about the ill-effects of the real brain drain, every effort will have to be made that the scholar from abroad is given a firm job offer in an appropriate company, university or research laboratory. In order to do this, the need for a formal interview before a selection committee at home may have to be waived. In the absence of a firm job offer in a suitable organization, the chances of the scholar returning to India are slim.

A flexible approach towards a job offer should also involve some 'perks'. One of the major worries of persons returning from abroad is that of finding suitable accommodation. An assurance about accommodation can go a long way in ensuring the return of a person. An additional incentive to return can be provided by paying the travel fare for returning to India.

Retaining the Talent

Since the person working in India does so at a considerable monetary loss, it is imperative to try and create a working environment in which his ambitions for doing first rate research are satisfied. All research workers require some time to settle down in a new environment and the young persons we are dealing with in the present situation are no exceptions. It could take anything upto one year for them to obtain funding for their research work from external agencies. In the mean time, it is highly desirable that they be provided with some 'seed' money for beginning their work so that they do not get frustrated and impatient. A grant of Rs. 50,000/- or Rs. 1 lakh can go a long way in setting the young scientist on his path.

The other important aspect about retaining young talent is to permit them rather liberally to maintain linkages with the outside world. Attendance at international and

domestic conferences and workshops has to be made easier for this select group. In particular, visits abroad for exchanging views and seeking information in rapidly advancing areas of science and technology are very critical.

Administering the Scheme

In order to be successful, the proposed scheme would need to be administered by a well knit organisational set-up having a national level framework. CSIR would probably be the proper forum for coordinating such an effort. An alternative is the Department of Science and Technology which is also concerned with the development and growth of S&T manpower. A large non-governmental organization could also be involved with the task of operating the scheme.

It is estimated that in a given year about four to five hundred names would be added to the database of outstanding scholars. It is expected that a selected person will continue to be on the list for about seven or eight years. An age limit of 30 years could be prescribed. By this age, it is expected that the scholar will have completed his education and settled down in a job and career. Thus once the scheme is in full operation, one can expect about two to three thousand names on the active list. Given this size, it is clear that a very large set-up is not required for administering the scheme.

Concluding Remarks

For too long has the Indian nation been under the illusion that having one of the largest pools of manpower in science and technology is adequate for maintaining our position in science and technology *vis-a-vis* other countries. There is clear evidence[5] that India's share in the world's scientific output has declined sharply in the last fifteen years when considered in terms of publications in standard international journals. It is thus apparent that we need to consciously encourage the growth of quality. The adverse influence of the 'real' brain drain on our scientific and technological research has been decidedly alarming and it would not be wrong to say that over the last two decades we have almost completely lost one generation of our most talented young scientists and engineers. We really cannot afford to continue this way.

REFERENCES

1. S.P. Sukhatme and I. Mahadevan, 'Pilot Study on Magnitude and Nature of the Brain Drain of Graduates of the Indian Institute of Technology, Bombay,' Report submitted to the

Department of Science and Technology (1987)

2. S.P. Sukhatme ' A Study on the Nature of Work and Placement of Postgraduate Alumni of the Indian Institute of Technology, Bombay,' Report submitted to the Department of Science and Technology (1990)

3. S.P. Sukhatme and Indira Mahadevan, 'Brain Drain and the IIT Graduate', *Econ. Pol. Wkly.*, **23** (1988) p.1285

4. S.P. Sukhatme, *The Real Brain Drain*, Orient-Longman, Mumbai (1994)

5. N. Raghuram and Y. Madhavi, 'India's declining ranking', *Nature*, **383** (1996), p.572

Brain Drain
Some Personal Thoughts

E.D. Jemmis, FNA

School of Chemistry, University of Hyderabad,
Central University PO, Hyderabad 500046, India

Nurturing Talent

To drain or not to drain we need to have talented young people. Ideally the process of nurturing talent should begin at the very beginning. Long term planning is needed here. It is possible to have long debates and discussion on these issues and arrive at a course of action. However, this is going to take time. Instead of lamenting about the slowness of this process, one may begin with the existing programmes. One of the existing programmes in this direction is the chain of Navodaya Vidyalayas. These should be closely monitored so that they train the best of students. Another programme that has worked very well during the 60's and 70's is the National Science Talent Search Scheme of NCERT. I feel passionately for this and would like to describe my experience which may help in reformulating the scheme. This has been diluted during its expansion to the National Talent Search Programme. This reason for this statement is the following. Professional courses such as medicine and engineering do not need such special provisions. A large number of good students are any way going to opt for them. Basic Sciences are seen as a secondary option. In such a situation the National Science Talent Search Scholarship Programme will help in attracting good students to Science. Let me recollect the process involved in the National Science Talent Search Scheme of the late 60's and 70's lest the details are forgotten.

Following a general national call for applications, a nationwide test is conducted. Along with the examination an independent scientific project

is to be carried out and the report submitted. There were no further guidelines. I still remember all of us reading everything that we can lay our hands on looking for a project in the 12th year of school. Perhaps this can be done in the 10th class as well. It forced students to look beyond the class room. On the basis of the written test and the project, students are invited for an interview. This was again held in the leading research institutions of the country. In 1968, this was held in the Indian Institute of Science, Bangalore. Those selected were notified through the Newspaper, by giving names and also individually. The whole process of applying and going through the procedure is in itself an educating process, many of my classmates who didn't make it in the interview agreed. The Scholarship came in an attractive bundle. It paid for the B.Sc. education including boarding and lodging with many additional benefits—a book grant, summer school of four month duration every year, a professor to take care of you (for which he or she is paid an honorarium), study in select institutions where admission is practically guaranteed, continuation of Fellowship at an attractive level for M.Sc. and Ph.D. if one maintains a first class. This latter aspect is very important. One is relatively free to study what one wants in addition to the syllabus. This helps in broadening one's interests and also specializing in what one likes. In other words, one can be outside the rat-race of getting higher marks for its sake and still have a future in science, if one makes it to the list. To be even more specific about the monitory incentive, let me give the CSIR JRF and the NSTS Ph.D. Fellowship prevailing in the early 70's. The former was RSV 250.00 and the latter RSV 400.00. This is in addition to the book grant and the contingency.

Of course, much depends on the way the programmes are executed. For example let us take the summer schools. I had to say that these were conducted with such enthusiasm that many details still linger in my mind. It is only fare that I thank the many people who helped shape many young minds by actually writing about them. We had the first summer school in chemistry in Chandigarh in 1969 summer. This was directed by Professor R.C. Paul of the Department of Chemistry, Panjab University. The invitation letter, after describing the way to reach the campus, states: "intelligent as you are, I am sure that you will not have any problem in getting here." This was topped only by the letter that we received soon after we reached home after the summer school. This ended by the statement "either you should not have come or you should not have gone." Several of us had developed such close interactions with the teachers that we

echoed those sentiments. Dr. Ashok Kumar Sharma was the overall in-charge of these summer schools.We had another summer school in Chandigarh in 1971. The impact of these summer schools were dramatic. Even today I can recollect the names of the several teachers who has taught me during those two months in 69 and 71—Lakhan Pal, Shyam Vasisht, Gurdev Singh Chadha, D.V.S. Jain, A.K. Sharma, R.C. Paul and others come to mind effortlessly. The summer school at the University of Pune in 1970 was equally exciting. The Director, Professor Phansalkar and his team that included Professors Wadia, Dedgaonkar, Narlikar and others instilled in us such an excitement for research that many of us continued in this line. These summer schools were very enjoyable even outside science. There were several cultural evenings which brought the best of the youngsters coming from various places in the country. We were taken to important places and institutions around (Golden Temple, Simla and Kasauli, Lonavala, NCL etc). The impact on young minds of all of these were dramatic. I can still recollect several names form our chemistry batch of that year that went on to make a career in science (these include Brahmachary, Vijayaraghavan, Prabir Dutta, Sreekumar, Riputhaman Malhotra, N. Kumar, G.M. Joshi, A. Sen, Yasmin Jayathirtha Rao, Abhijit Mitra, P. Rajasekharan Pillai, M.V. Rajasekharan, P.K. Swaminathan, and so on). Many of them would have opted for IITs and for medicine if the NSTS programme didn't exist.

The summer schools also provided much needed advice about further course of action. For example, in 1971 summer school when we were all looking for places to study for M.Sc., there was such clear suggestion from Professor R.C. Paul that many of us applied to IIT Kanpur. In fact, out of the 14 or so of the 71-73 batch more than 10 were NSTS Scholars.

The NSTS programme had also built a sense of commitment through its various activities. (1. Fellowship offered till the end of Ph. D. Programme starting at 1st year B.Sc. 2. Summer School of four weeks during the B.Sc. and M.Sc. studies. 3. Book grant. 4. Honorarium to the Professor who guided the student during B.Sc. 5. Insistence of study in select institutions in each State wherever possible). Even those who went abroad and settled there speaks very fondly about the programme. They would happily contribute financially to such a programme, if they are approached. The reasons for going through these in as much detail as I can remember is the following. We often talk about many programmes and many of them don't even take off. Here is a tested method which can be started without any

lengthy discussion. It can be modified on the way.

The only programme that goes along similar lines is the contact programme of DST at the I M.Sc. level. This is in a very small scale and for a very short duration. There is no cumulative effect of attending 5 four-week summer schools by the end of the B.Sc./M.Sc. period. The contact programme is better than not having anything, but not a substitute for NST summer schools.

For want of another forum, let me give another problem that is faced by a student who is at the end of the 12th year of schooling. Whatever he wants to do, a plethora of entrance tests have to be taken. Somehow nobody is willing to take trouble to think about their plight even though they have to decide the destiny of this country. We are eager to imitate everything from the west but not some well proved and time tested strategy from them. I am referring to the SAT and its equivalents of the USA. We need something similar here. Again, instead of debating for another ten years about creating something new, we should check what is around. In physical sciences, the best all-round estimate is being made by the JEE of the IIT's. All engineering and physical science admissions should be through these rankings. Obviously this will increase the burden of the JEE-IIT system, but these are the only organizations with the required know-how right now. This will eliminate the many entrance examinations every state and many universities conduct. A similar one can be conducted for biological science and these rankings should be made compulsory criterion for all admissions to undergraduate programmes in the country, whether it is for medicine, engineering or sciences. It would be an enormous savings for the energy and other resources in the country. This is much less difficult than one imagines. If our own institutions shy away form this duty of conducting the examination, there is the unwelcome alternative of accepting the SAT score of the Educational Testing Service of Princeton. Whether one likes it or not, in this age of liberalization, many private institutions will follow that pattern if no indigenous mechanism comes up. Then again, IITs already use it to admit NRIs. But I am sure that the JEE-IIT and the JIPMER or equivalent test for biology together will serve better for the entire nation.

Is Brain Drain a Problem ? A Problem for Whom ?

Let us now come to the exodus of the intelligent mind away from the country. Being the last person of the day, I have tried to avoid repetition by removing the many points raised by the previous speakers. This doesn't

leave much. But let me give some points that has been troubling me. Brain Drain may be seen as a problem for the Country by concerned Scientists. In families, especially in rural areas, where togetherness is associated with nearness, brain drain may be considered as an unwelcome emotional drain. But the Indian at large does not consider it as a problem. A child abroad is the in-thing in society for various reasons. We all know the lengths to which parents go to get a child abroad. Brain Drain is a problem, a handy one at that, when the public collectively want to show that leading educational institutions are useless because all their students go abroad. It also helps in making sensational headlines in the papers by giving the percentage of students from good institutions who go abroad. At an individual level most want their children abroad. Thus Brain Drain cannot be solved from the synergy coming from the public at large. It may be reduced by getting the scientist from the young age involved in the scientific life of the country and making him feel wanted as in the letter of R.C Paul mentioned earlier,"...either you should not have come or you should not have gone. "

Who goes Abroad and Why?

The major groups that go abroad can be broadly classified into three categories: (a) Graduate study, (b) Post doctoral work, (c) Undergraduate study. Several factors my be common amongst these groups, but there are differences in the thoughts that lead to their decisions to go abroad. One or more of the factors below might influence the decisions of students who go abroad for graduate study; (a) All my seniors have tried; let me also try, (b) America (or country X) is fascinating, (c) 'Many parents encourage to go abroad' is not a considered one. More than the lack of facilities at home, it is the perceived lack of facilities formed by the negative attitude of the older generation, that be a large contributor to the decision of this group. The many factors that drive the recent Ph.D.'s to go for post-doctoral work include the following : *(a)* immediate lack of job opportunities; *(b)* importance of exposure to a new lab, new area, new system, new country; *(c)* the preference for PD experience abroad for jobs within the country; and *(d)* Source of some savings to start back at home. Those who opt for undergraduate study is limited to the very rich (even though this has started changing in recent years) and in general their percentage in pure science is not very large. However this number is going to expand exponentially unless we get our system changed as quickly as possible. Most other countries are doing everything possible to attract the Indian student for undergraduate study. The

students will go because, except for a few institutions, this is the weakest link in the higher education scene in the country. I do hope that 5NSTS scholars in a class of 50 regular students can make a large difference to the class. They could be instruments of change.

Staying on *vs* Getting Back

Graduate students abroad have somewhat different mental make up in thinking about going back home. Most of them go abroad without any preconceived notions of staying one. The fascination, novelty and comforts remain as major attractions only for three or four years. Here one finds that those coming from more affluent families tend to value the comforts to a greater extent and tend to stay on permanently for this reasons. Those who get married and having children at this stage usually stays on for better health, education, insurance and other aspects of the life abroad. Often the right job at the right time could make all the difference in the decision to come home. Lingering scientific contacts such as the link established by the five summer schools by the NSTS would also tilt a decision in getting back after Ph.D. Most scientists who go abroad after Ph.D. has a different way of looking at this process. They have spent many years doing research at home and have experienced the advantages as well as the disadvantages of it. Some would have already decided that if there is a choice I would not get back. There are others who are confident to return and make it in the Country. In either case the decision is made with the help of their direct knowledge of the research apparatus of the country. It is good if only those who strongly feel to return, return. Otherwise life will be miserable to them and those around. Admittedly these are oversimplified observations on a complex issue.

Once Back

The shortcomings of the scientific research establishment have been debated so frequently that there is no need to reiterate them. I only have the following additional point to make. The administering of a research project funded by an external agency is a very time consuming process in most institutions. The energy wasted .in this process is enormous. Any attempt to reduce this would help research in the country. Some suggestions in this line are —1. Allotment of specific funds for connection with the actual process of doing research, done). 2. Willingness to do away with the lowest quotation mania, if the situation so demands. 3. Encouragement of private funding (from industry and other philanthropic groups) without any strings attached to scientists who have shown their credibility in science and spending for science.

Conclusion

Make science exciting for the young. Start this process early in the career. The National Science Talent Search Scheme of the kind operated in the late 60's and early 70's is a possibility. This may be started in the 10th as well as in 12th. It is a tried and tested one, diluted in more recent years, reducing its impact to a minimal level. A long term plan to change the educational institutions to ideal ones is needed but one should never wait for this to happen to nurture talent. Rest of the improvements are needed but not as crucial as instilling a love for science in the young minds. ☐